



Engine Test Facility

The Air Force Arnold Engineering Development Center's Engine Test Facility (ETF) test cells are used for development and evaluation testing of propulsion systems for advanced aircraft and missiles. These propulsion systems include turbojet and turbofan air breathing engines and ramjets.

Ground tests of air breathing engines provide information such as performance, operability and reliability and can help cut development time and the number of flight tests required for manned aircraft or unmanned weapon systems such as cruise missiles and unmanned aerial vehicles (UAVs).

The tests may involve complete flight-type engines or heavier boilerplate versions in which inlets, compressors, combustors, nozzles or other components can be installed for experimental investigation.

Background/History

World War II ended with air power fully recognized as a controlling factor in warfare. Nearly one-half century had been devoted to developing and perfecting the conventional airplane. New technologies emerged from World War II shifting the world's aeronautical effort to high subsonic, transonic and supersonic flight.

At that time, the United States lacked the test facilities necessary to ground test the developing and envisioned high-performance jet engines.

The Germans recognized the need for special facilities for jet propulsion development. In 1944, they placed in operation the Bavarian Motor Works (BMW) engine test plant to test and develop gas turbine engines.

After the war, the BMW plant was dismantled and shipped to the U. S.



Photo no. 96-177210

The Pratt & Whitney F119 engine, powerplant for the Air Force's F/A-22 Raptor air dominance fighter, undergoes testing in the Aeropropulsion System Test Facility's C-1 Test Cell.



Photo no. D0307486

The Pratt & Whitney F100-PA-220 engine, powerplant for the F-15 Eagle and F-16 Fighting Falcon fighter aircraft, undergoes sea-level Component Improvement program RAM testing in Sea Level Test Facility SL-2.

In January 1949, AEDC's Engine Test Facility was approved by Congress, and in September 1950, the Air Force began reconditioning and installing the BMW equipment at AEDC.

The German equipment was modernized and expanded considerably during its installation at AEDC. Shakedown testing of ETF began in July 1953, and on May 3, 1954, the first turbojet engine test operation of a J-47 engine (later used to power the B-47 Stratojet bomber) began in ETF T-1 test cell.

Air Breathing Engine Testing

Instrumentation is attached to jet engines, which are then mounted on thrust stands and installed in test cells. In some tests, screens are installed in front of the



Photo no. DSC00048

Technicians prepare an Engine Alliance GP7200, one of the powerplants for the Airbus A380, for performance and operability testing at simulated high altitude in the Aeropropulsion Systems Test Facility C-2 test cell. The engine was instrumented with more than 4,200 data channels to gather information during the test providing information to allow the Engine Alliance to optimize various engine designs.

test engine to simulate the airflow characteristics of the aircraft inlet. Also, in-flight icing conditions are simulated with a water atomizing system placed in front of the engine. The engine is then operated as the air supply compressor and exhaust systems are regulated to simulate flight conditions with controlled airflow rate, temperature, pressure and velocity called for in the test plan. Gas turbine, turbojet and ramjet engines are essentially air machines whose performance is dependent on pressure, temperature, mass airflow and moisture content of air.

Engines are tested throughout their specified flight envelopes including critical areas which represent the limits of their performance. A wide range of flight conditions can be simulated but, generally, the limit for testing air breathing engines is less than Mach 3.8 at simulated altitudes below 100,000 feet.

Test information is provided by the instruments installed in and around the engine. Several hundred instruments are installed on the engine to measure forces, pressures, temperatures, vibrations, liquid and gas flow-almost everything that goes on in the engine and test cell. While undergoing tests, engines can be observed visually through test cell observation ports or on control room monitors using TV cameras placed in the cell and exhaust ducting. High-speed or real-time motion picture and video cameras are also used for post test analysis. All test

cell conditions are monitored from control rooms adjacent to the cells.

Some of the world's largest jet engines have been tested in the Aeropropulsion Systems Test Facility (ASTF) portion of the Engine Test Facility. Those include the PW4000 series engines and Rolls-Royce Trent 800 used to power the Boeing 777 as well as the Rolls-Royce Trent 900 and Engine Alliance GP7200 used to power the Airbus A380.

Engines for the development of our nation's most vital aerospace weapons systems have been recently tested in ETF as well. Among those are the Pratt & Whitney F119 engine used to power the F/A-22 Raptor and the Pratt & Whitney F135 engine used to power the F-35 Joint Strike Fighter.

ETF's SL-2 and SL-3 sea-level test cells provide the capability to operate at either ambient sea level condition, variable temperature ram inlet conditions, or heated inlet sea level conditions without ram and to rapidly transition between those test configurations.

The two cells are capable of testing up to 50,000 pound thrust engines at ram speeds up to Mach 1.25 and temperatures ranging from minus 65 degrees to 350 degrees Fahrenheit.

Another sea level test cell, SL-1, has the capability to operate at sea level conditions in an economical T-9 hush house configuration. These capabilities are especially critical for economically simulating flight conditions in a ground test facility and rapidly accomplishing Accelerated Mission Testing (AMT) or Accelerated Simulated Mission Endurance Testing (ASMET). These tests evaluate engine durability by duplicating the types of missions the engine will actually fly in operational service.

ETF has been instrumental in making AEDC more competitive in test and evaluation of large turbofan propulsion systems. Public law allows U. S. government agen-

cies and facilities to open their doors and technology to American industry. One of the first contracts in the early 1990s under this law was with Pratt & Whitney for development testing of the PW4000 series engines in Test Cell C-2 to determine the engine's operational characteristics and qualify them for flight. The PW4084 engine which is nearly 10 feet in diameter was selected by United Airlines as the powerplant for the twin-engine Boeing 777 wide body jetliner.

Analysis and Evaluation

A strong analysis and evaluation capability complements ETF's ground test capabilities.

The analysis and evaluation mission is threefold. The primary mission is to conduct independent technical assessments of turbine engine systems. These assessments, including product verification and qualification and specialized data analyses, are performed at the request of Air Force's product divisions and other federal agencies.

Another mission objective is to assist



Photo no. 95-072119

An AEDC lead mechanic discusses testing of the Pratt & Whitney TF33 engine which powers the B-52H Stratofortress and KC-135 Stratotanker with a KC-135E pilot from the Alaska Air National Guard's 168th Air Refueling Wing, at Eielson Air Force Base, Alaska. This test was conducted to baseline the engine's cold weather starting capability and range of performance.

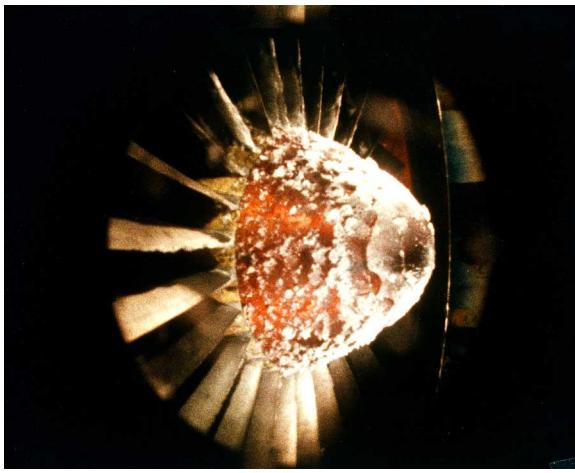


Photo no. 70-1121

Ice buildup on TF-39 compressor centerbody during a 50,000-foot altitude simulation engine icing test in the center's J-1 engine test cell.

in the advanced engineering development of new aerospace propulsion systems and to improve the test and evaluation capabilities. AEDC provides engineering assistance to the product divisions during development programs through support of detailed design reviews and source selection activities.

The center is also responsible for establishing and maintaining a center of analytical expertise in mission/propulsion-cycle simulation, aerothermodynamic modeling, structural assessment, controls evaluation, systems performance/operability analyses, and systems observability that affect the aerodynamics of the flight vehicle.

AEDC

AEDC is the most advanced and largest complex of flight simulation test facilities in the world with 58 aerodynamic and propulsion wind tunnels, rocket and turbine engine test cells, space environmental chambers, arc heaters, ballistic ranges and other specialized units. Twenty-seven of the center's test units have capabilities unmatched in the United States, 14 are unique in the world. AEDC's facilities can simulate flight conditions from sea level to 300 miles altitude and from subsonic velocities to well over Mach 20.

The AEDC mission is to:

- Test and evaluate aircraft, missile and space systems and subsystems at the flight conditions they will experience during flight to: help customers develop and qualify the systems for flight, improve system designs and establish performance before production; and to help users troubleshoot problems with operational systems
- Conduct a research and technology program to develop advanced testing techniques and instrumentation, and to support the design of new test facilities.
- The continual improvement helps satisfy testing needs and keeps pace with rapidly advancing aircraft, missile and space system requirements
- Maintain and modernize the center's existing test facilities

AEDC, an Air Force Materiel Command Facility and an important national re-

source, has contributed to the development of practically every one of the nation's top priority aerospace programs including the Atlas, Titan, Minuteman and Peacekeeper ICBMs, Project Mercury, Gemini and Apollo as well as the space shuttle and international space station. Aircraft include A-10 Thunderbolt II, AV-8 Harrier, E-3A Sentry, EF-111 Raven, F-14 Tomcat, F-15 Eagle, F-16 Fighting Falcon, F/A-18 Hornet and Super Hornet, F/A-22 Raptor, F-35 Joint Strike Fighter, F-111 Aardvark, F-117 Nighthawk, C-5 Galaxy, C-17 Globemaster III, C-130, C-141 Starlifter, B-1 Lancer, B-2 Spirit, B-52 Stratofortress, KC-135 Stratotanker, T-38 Talon and the V-22 Osprey.

Other systems include the Global Hawk, Navstar Global Positioning System satellites, the GOES-M weather satellite, the Inertial Upper Stage; Trident submarine launched ballistic missile, Tomahawk, Air-Launched Cruise Missile and the Advanced Medium-Range Air-to-Air Missile.

Customers include the Department of Defense, Army, Navy and Air Force organizations; the National Aeronautics and Space Administration, both domestic and foreign private industry, allied foreign governments and educational institutions.



Photo no. D0306985

An AEDC craftsman examines the General Electric F404-GE-402 engine in AEDC's T-4 Propulsion Development Test Cell. The engine, which powers the Navy/Marine Corps F/A-18 Hornet, underwent development testing at AEDC.



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